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DESIGN AND PERFORMANCE OF AN INDUCTIVE CURRENT PROBE INTEGRATED INTO THE TRACE SUSPENSION ASSEMBLY

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As disk drive data rates approach 1 Gbit/sec, design and optimization of the recording channel is an ever increasing challenge. The challenge is compounded by the time-varying nature of the head impedance; The finite response time of the magnetic head materials implies that steady state assumptions as to the head reactance are invalid. It is therefore necessary to measure the current flowing into the head in response to the drive voltage to characterize recording channel performance. We describe an integrated approach to the design of a current probe that is fully compatible with trace suspension assemblies (TSAs). This approach has the advantage of high bandwidth, high sensitivity, low complexity and *in situ* placement on TSAs.

Waveguide structures can efficiently couple microwave fields into magnetic materials [1]. In the case of thin metallic magnetic films, the inductive load presented by the magnetic material is only a perturbation to the waveguide impedance [2]. It is therefore possible to use a thin magnetic film to act as a non-intrusive inductive transformer in order to couple two waveguides together. Since the trace structure found on high performance TSAs are essentially waveguide structures, it should be possible to incorporate a thin-film transformer structure into the TSA design through a simple modification of the trace layout. A simplified schematic of one such design is shown in Fig. 1. We only show the write circuit and current probe traces for the sake of simplicity. In this example, one of the write traces is coupled to one of the current probe traces with a thin film ferromagnetic chip which overlaps the two sets of traces.

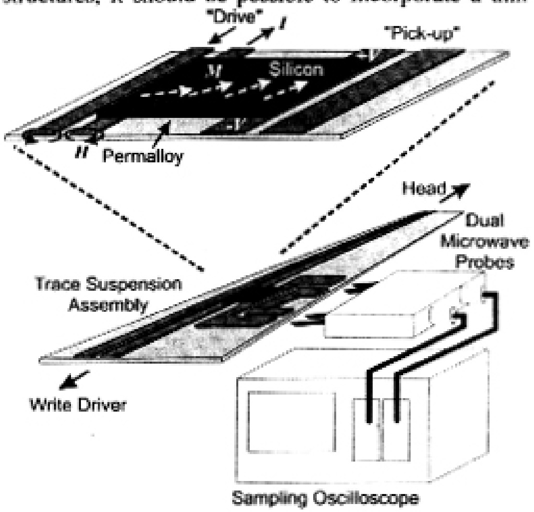

Fig. 1. Schematic of inductive current probe design for integration into TSA structures.

When current is driven through the write traces, it generates a magnetic field which swings the magnetization in the overlapping film transverse to the trace direction. This launches a magnetostatic wave toward the pick-up traces. When the magnetostatic wave arrives at the pickup trace, an inductive voltage is produced. The inductive voltage has odd symmetry with respect to the position of the sample [2]. This produces two microwave pulses, each of which travels in an opposite direction along the pick-up waveguide. To detect the inductive signal, two sets of microwave probes extract both pulses from the waveguide. The two pulses are then measured with a sampling oscilloscope. By subtracting the two pulses from each other, the total inductive signal can be measured. The advantage of this approach is the ability to remove common-mode signals generated in the pick-up waveguide as the result of stray capacitive coupling. It is this capability to separate capacitive from inductive sources of signal that distinguishes this approach from more conventional current probe designs [3].

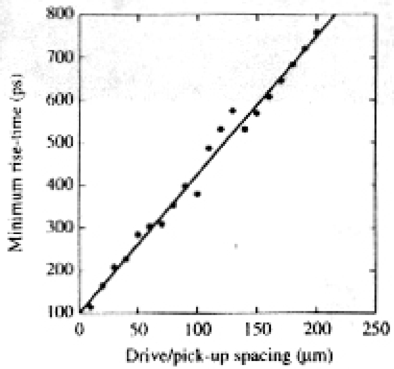

Fig. 2. Calculated response time of inductive current probe. Material parameters are typical for Permalloy.

The bandwidth of the such a thin film transducer is determined primarily by the ferromagnetic resonance properties of the magnetic material. Standard mathematical methods may be used to estimate the bandwidth for a variety of material properties [1]. We begin with the usual dispersion equation for surface magnetostatic modes, simplified for the case of long wavelength excitations in a high moment, low anisotropy film:

$$\omega(k) = \gamma\mu_0\sqrt{M_s\left(H_k + \frac{1}{2}M_s\delta k\right)}, \tag{1}$$

where γ is the gyromagnetic ratio, μ_0 is the permeability of air, M_s is the saturation magnetization of the film, H_k is the intrinsic anisotropy, δ is the film thickness, and k is the wavenumber. From eq. (1), we find that the group velocity v_g for a given frequency is $v_g = \omega_0^2\delta/4\omega$, where $\omega_0 = \gamma\mu_0 M_s$. Small magnetic excitations decay with a characteristic time τ of $\tau = 2/\alpha\omega_0$, where α is the Landau-Lifshitz-Gilbert damping constant [2]. It may then be shown that these excitations propagate as $e^{i\tilde{k}x}$, where $\tilde{k}$ is the complex propagation constant.

$$\tilde{k} = \frac{2\omega(2\omega + i\alpha)}{\delta\omega_0^2}. \tag{3}$$

Using (3), we can numerically calculate the effect of propagation upon magnetostatic waves launched at the drive waveguide and received at the pick-up waveguide. In Fig. 2 are the results of a calculation for a 700 nm thick Permalloy film with $\alpha = 0.1$. We see that rise-times of 250 ps are possible if the distance between the drive and pick-up traces is kept to less than 50 μm.

References

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